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Effect of Drought Stress on the Morphological and Physiological Characterization of the Indian Wheat (*Triticum aestivum* L.) Genotype

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A B S T R A C T

Wheat is an important cereal crop of world including India. The major problems of drought condition in India therefore wheat have a low productivity, so we would like to develop drought tolerant crop varieties through help of various verities. In which present study we have used ten wheat genotypes of diverse genetic background with popular cultivar of India. All the genotypes had screened accordingly morphological, physiological characterizations for drought condition. On the basis of morphological and physiological traits it was observed that genotypes Raj 1555, DBW17, PBW226, VL 421, PDW 291 and WH1021 performed better for drought induced conditions.

Introduction

Wheat (*Triticum sp.*) is an important cereal crop of the world and ranked second most important source of staple food crop in India often rice. It is unique in several features. It is the only crop to have produced more than 500 million tonnes in a single year and to contribute more calories and more protein to world's diet than any other food crop. (Breiman and Graur, 1995) The major wheat growing areas in India are located in the northern regions of the country. The state of Uttar Pradesh produces the most wheat in India, accounting for 35% of India's total wheat production. The effects of drought on yield of crops depend on their severity and the stage of plant growth during which they occur. Seed germination is the first stage of growth that is sensitive to water deficit. Under semi-arid regions, low moisture is often a limiting factor during germination. The rate and degree of seedling establishment are extremely important factors to determine both yield and time of maturity (Rauf *et al.*, 2007). It simply that systemic, deeper and comprehensive understanding of physiological mechanism in crops under drought stress is not enough to manipulate the physiological regulatory mechanism and take advantage of this

potential for productivity, study of which is the bridge between molecular machinery of drought and anti-drought agriculture because the performance of genetic potential of crops is expressed by physiological realization in fields (Shao *et al.*, 2005). Drought susceptibility of a genotype is often measured as a function of the reduction in yield under drought stress, whilst the values are confounded with differential yield potential of genotypes (Ramirez and Kelly, 1998).

Materials and Methods

In the present study, a total of ten genotypes in the area of western Uttar Pradesh viz. HD 3967, HD 3967, HD 2733, PBW 550, PBW 226, DBW 17, WH 1021, HUW 234, Raj 1555, VL 421 were experiment trial was laid out in pots in three replications under rain out shelter at research field to seed were sown in pots.

Morphological evaluation of wheat genotypes

Observation of Morphological and physiological traits were recorded on randomly selected five plants from each tagged pots in each replication at deferent growth stage. The data was recorded for Pre-harvest characters like Plant Height **(**Plant height was measured in centimetre from bottom of the plant from soil level to the base of the spike.), Productive Tiller **(**Wheat seedling of different cultivars in their early stages of growth show marked difference in their growth habit. Number of tillers recorded at heading stage.), Days of Maturity It is number of days taken from to the browning of ear.), Length of Spikelet (Ear length is measured in centimetre from tips of apical spikelet (excluding awns) to the bases or collar of ear.), Spikelet per Spike (Number of spikelet present on spike is counted and mean of 10 spikes per genotypes is depicted in the text). For Post-harvest characters, the data was recorded for Seeds per Spike (number of seeds counted from 10 randomly sampled spikes at maturity is recorded as seeds per spike). Thousand Grain Weight (One thousand clean sun dried grain were randomly taken and weight in gm). Yield per plant (Weight of seed per plant expressed in grams) (Table 2).

Physiological evaluation of wheat genotypes

Chlorophyll content (SPAD meter) was used for chlorophyll estimation a leaf flag. Five flag leaves of each genotype grown in rain fed condition were measured after anthesis stage. Chlorophyll content recorded in percentages.), Related Water Content was determined by the method described by (Barrs and Weatherley, 1962). 100 mg leaf material was taken and kept in double distilled water in a Petridis for two hours to make the leaf tissue turgid. The turgid weights of the leaf materials were taken after carefully soaking the tissues between the two filter papers. Subsequently this leaf material was kept in a butter paper bag and dried in oven at 65^0C for 24 hours and their dry weights were recorded. The RWC was calculated by using the formula.

$$\text{RWC (\%)} = \frac{(FW - DW)}{(TW - DW)} \times 100$$

Where,
FW= Weight of freshly collected material.
TW = Weight after rehydration for 24 hours at 4^0C in the dark and.
DW = Weight after drying at 65^0C for 24 hours.

Statistical Analysis

The analysis of variance for the design of the experiment was carried out according to the procedure outlined by (Panse and Sukhatme, 1978).

Results and Discussion

Morphological characteristics

The plant height of all the genotypes was recorded at 60, 90, 120 and 150 after days. Mean of them were shown in (Table 1). a varied from the higher values are 78.6cm of two genotypes PBW226 and WH 1021 and lower values 58.3cm of DBW17 of irrigated (control) and higher value 63.3cm Raj 1555 and lower value 44.6 cm in drought condition and number of productivity tillers per plant was decreased in all the genotypes as drought applied except one genotype PBW 226 Maximum reduction in the number of tillers was observed in two genotypes HD 2733 and PBW 550. DBW 17 is the only genotype where no reductions of tillers were observed. Flag leaf area was varied and found values from 45.0 to 21.9 cm^2 for control and 36.6 to 17.2 cm^2 for drought. These results indicated the clear reduction of flag leaf area in all the genotypes when they exposed to drought conditions (Table 1 and Fig. 1c). Maximum flag leaf area observed in genotype Raj 1555 and minimum with HUW234 in both control as well as drought conditions. Leaf area of flag leaf is directly related to higher photosynthesis and chlorophyll content, hence affect the yield. As a result, genotypes Raj 1555 considered better as compared to other genotypes in terms of leaf area of flag leaf. Water stress reduces plant growth and manifests several morphological, physiological and biochemical alterations leading to massive loss in yield (Farooq *et al.*, 2009). Water shortage at critical growth stages such as crown root initiation, tillering, booting, anthesis and grain filling has deleterious effects on plant growth, development and economic yield of wheat (Khan, 2003; Manikavelu *et al.*, 2006).

Table.1 Pre-harvest characterization of wheat genotypes under irrigated and drought condition

Varieties	Plant Height		No. of Tillers		Leaf area		Day of maturity	
	Irrigated	**Drought**	**Irrigated**	**Drought**	**Irrigated**	**Drought**	**Irrigated**	**Drought**
HD3095	60.4	52.3	4.0	3.6	27.6	21.4	122	112
HD3967	65.3	58.4	4.0	3.6	24.2	20.3	128	106
HD2733	60.3	44.6	5.2	3	44.2	17.2	120	105
PBW550	60.4	52.4	5.2	3	37.6	23.7	121	105
PBW226	**78.6**	57.1	3.8	4	28.6	19.9	123	109
DBW17	58.3	44.6	3.0	3	23.0	18.5	122	115
WH1021	**78.6**	54.5	3.6	3	22.2	17.5	130	117
HUW234	60.0	52.5	3.6	3	21.9	17.9	128	120
RAJ1555	74.8	63.3	3.6	3.3	45.0	36.3	121	109
VL421	70.6	55.7	3.6	3	30.0	19.0	118	105

Table.2 Post-harvest characterization of wheat genotypes under irrigated and drought condition

Varieties	Length of spike		Spikelet per spike		Seed per spike		1000 Grain weight		Grain yield per plant	
	Irrigated	Drought	Irrigated	Drought	Irrigated	Drought	Irrigated	Drought	Irrigated	Drought
HD3095	10.5	9.8	16.0	13.3	32.0	33.3	34.4	31.7	13.55	12.28
HD3967	11.1	9.7	15.6	14.0	31.3	28.0	35.1	33.2	12.34	10.92
HD2733	11.5	8.3	16.3	13.0	32.6	29.0	36.2	34.1	12.31	11.10
PBW550	11.9	9.8	15.6	13.0	31.3	28.0	38.5	35.6	12.10	10.47
PBW226	12.2	10.0	15.3	9.3	30.0	22.6	36.9	33.9	11.73	7.68
DBW17	10.6	9.7	14.8	10.3	29.0	22.6	37.4	31.7	11.97	8.37
WH1021	11.5	10.6	17.3	14.7	34.6	24.0	38.0	34.9	13.40	8.05
HUW234	10.5	9.4	15.3	11.3	30.6	22.0	45.4	42.3	15.96	13.47
RAJ1555	10.5	9.6	14.3	14.0	33.3	28.0	42.2	40.0	11.13	7.42
VL421	11.7	10.6	16.6	13.3	33.3	26.0	44.5	40.2	18.03	14.05

Table.3 Physiological characterization of wheat genotypes (mean value) under irrigated and drought condition

Varieties	Relative water content		Chlorophyll content	
	Irrigated	**Drought**	**Irrigated**	**Drought**
HD3095	94.0	88.0	50.5	37.6
HD3967	81.7	76.6	52.2	50.2
HD2733	80.4	71.6	45.9	40.0
PBW550	74.1	69.9	47.2	47.0
PBW226	76.8	58.9	48.0	44.2
DBW17	80.0	69.1	51.8	40.2
WH1021	95.2	82.2	47.8	40.9
HUW234	80.0	75.0	40.3	42.6
RAJ1555	82.5	77.2	43.1	45.4
VL421	75.9	62.7	45.3	47.0

Fig.1a Plant height of different genotypes of wheat under irrigated and drought conditions

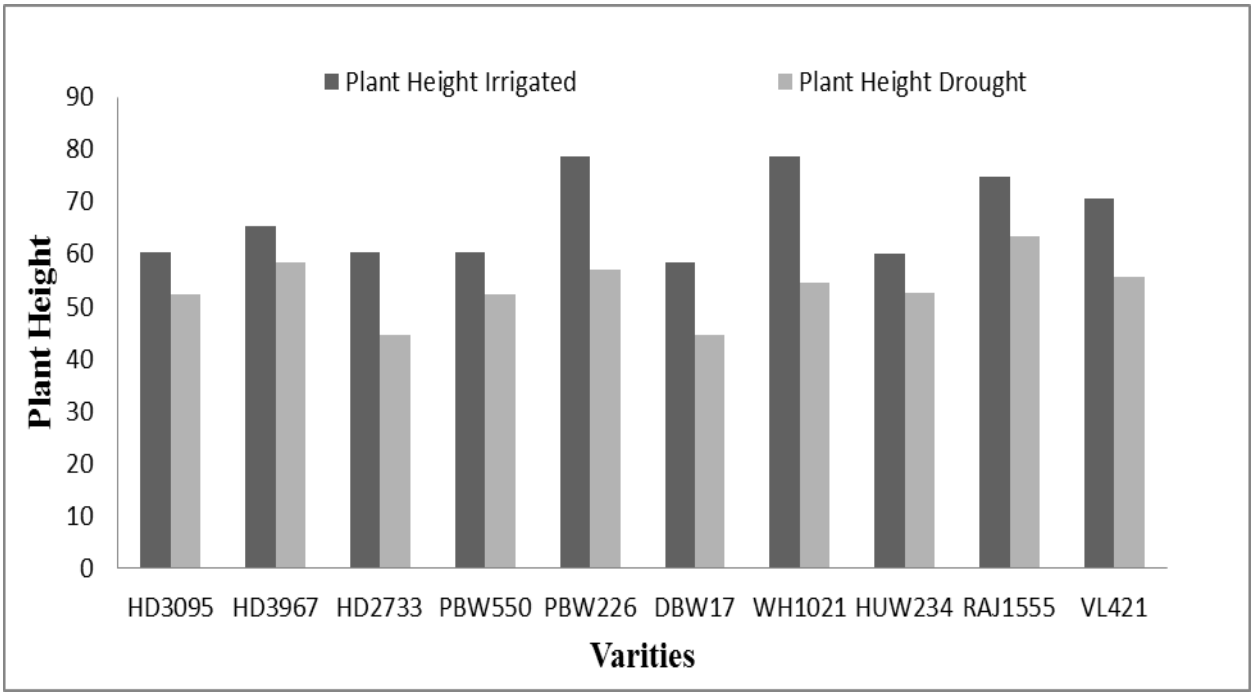


Fig.1b No. of Tillers of different genotypes of wheat under irrigated and drought conditions

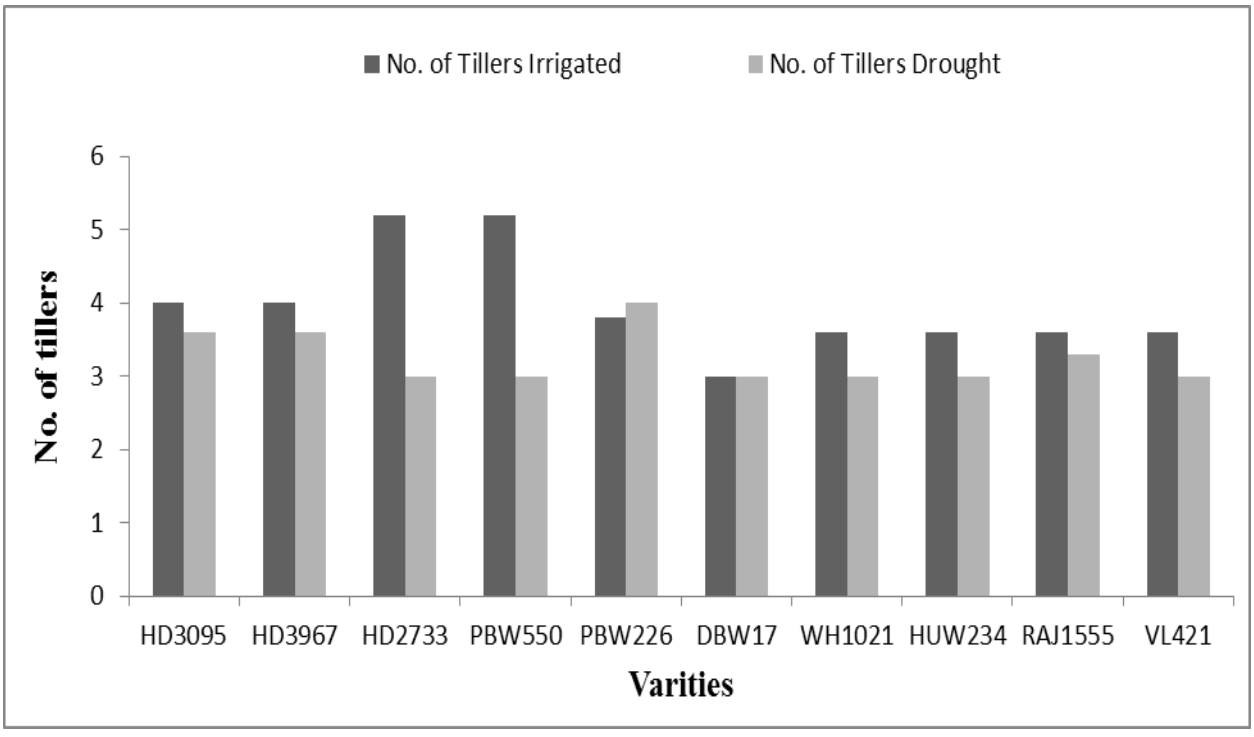


Fig.1c Leave area of different genotypes of wheat under irrigated and drought conditions

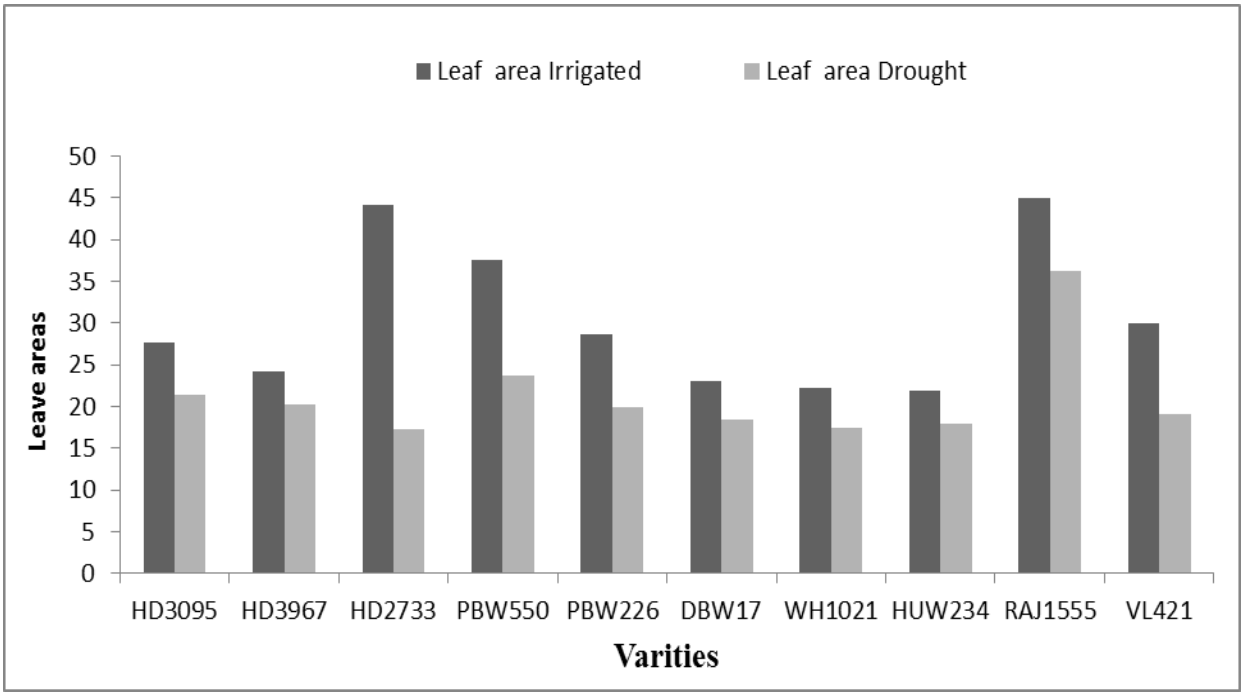


Fig.1d Days of maturity of different genotypes of wheat under irrigated and drought conditions

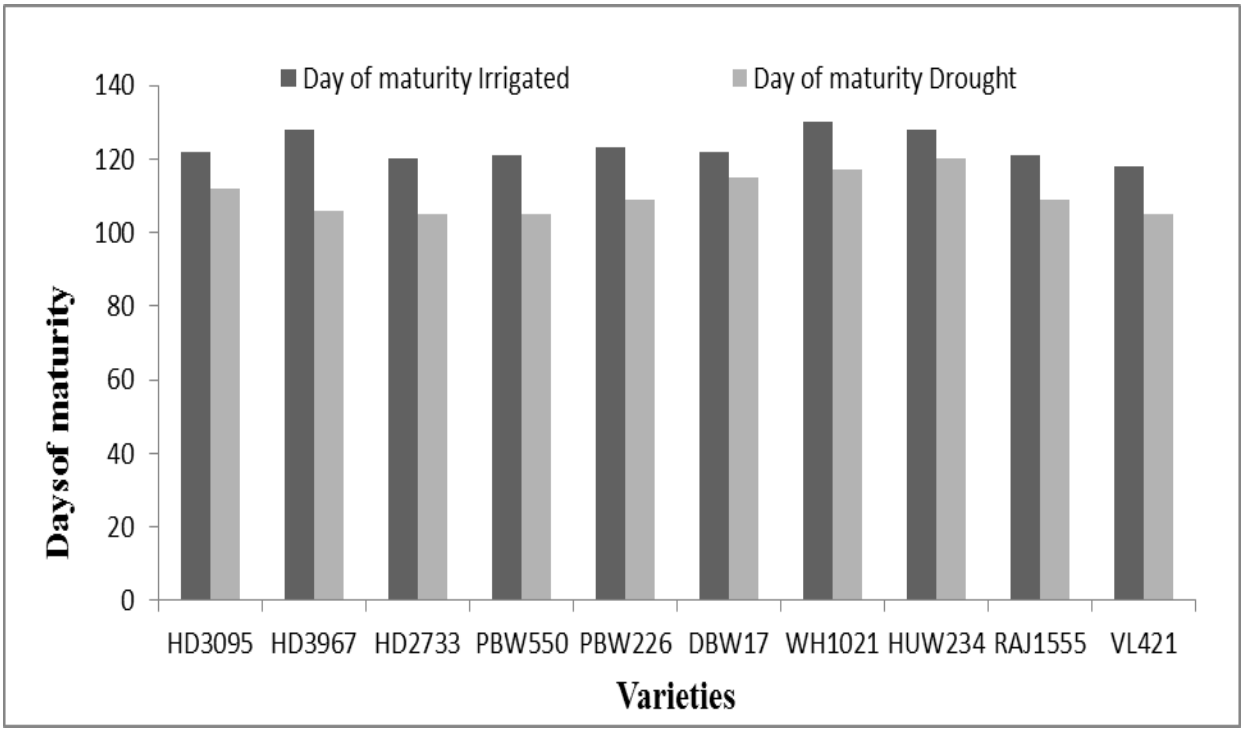


Fig.2a Length of spike (b) Spikelet per spike, (c) Seed per spike. (d) 1000 Grain weight, (e) Grain yield per plant of different genotypes of wheat under control and drought conditions

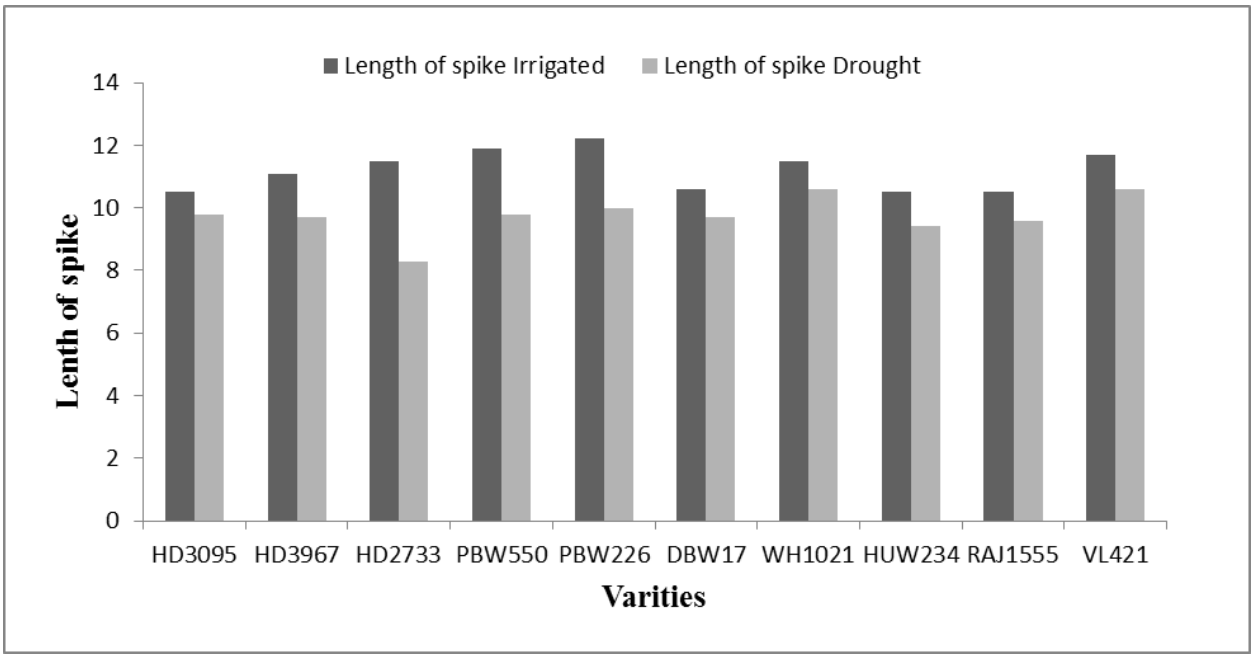


Fig.2b Spikelet per spike, per plant of different genotypes of wheat under control and drought conditions

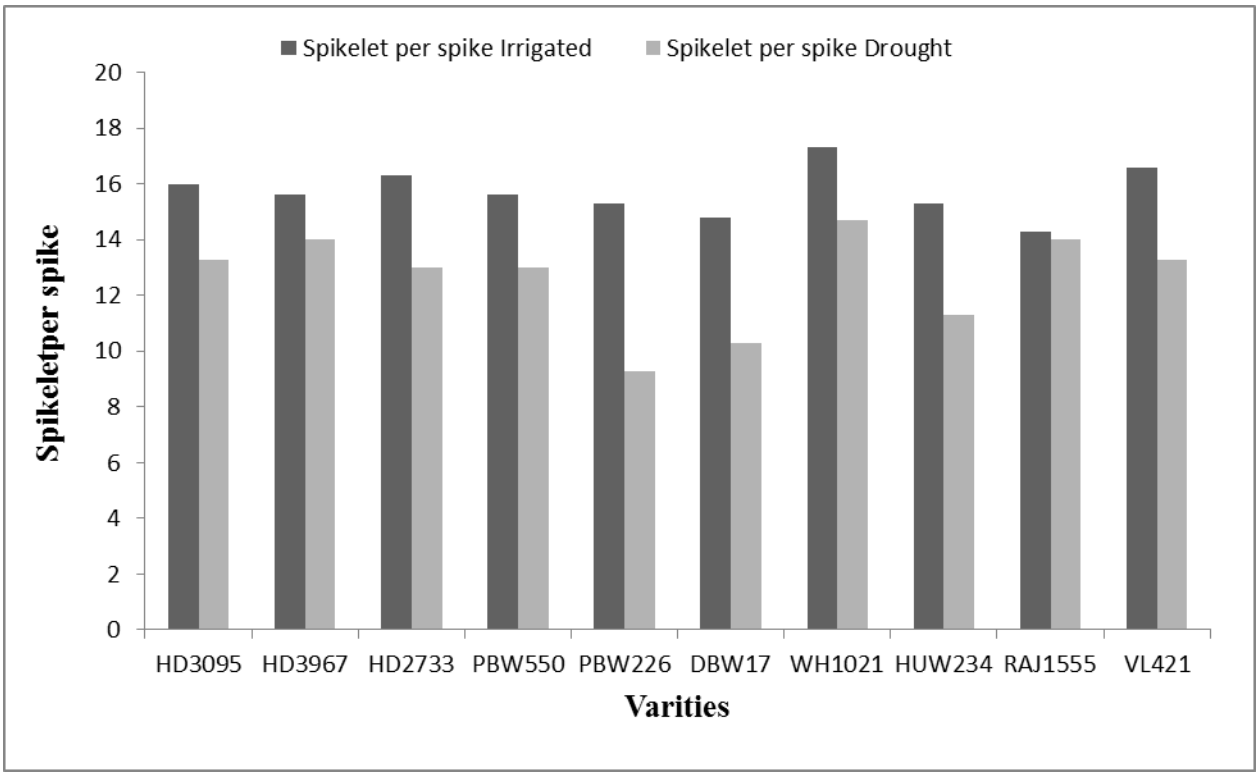


Fig.2c Seed per spike per plant of different genotypes of wheat under control and drought conditions

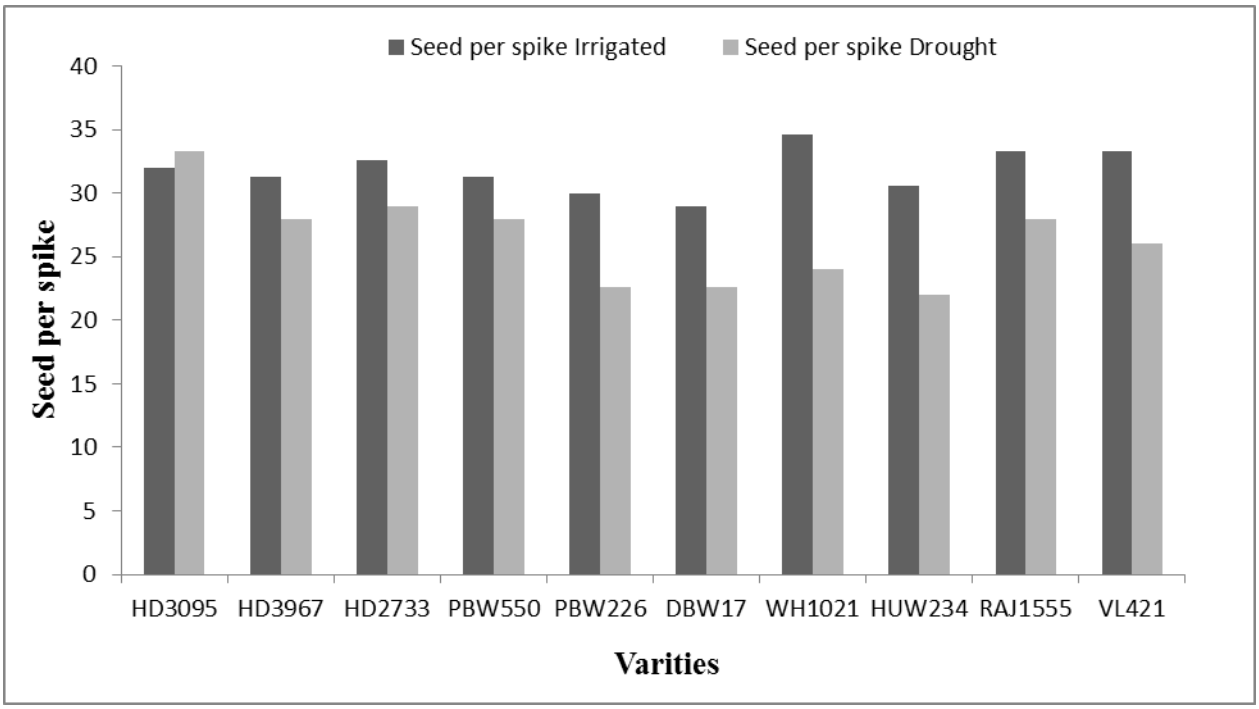


Fig.2d 1000 Grain weight per plant of different genotypes of wheat under control and drought conditions

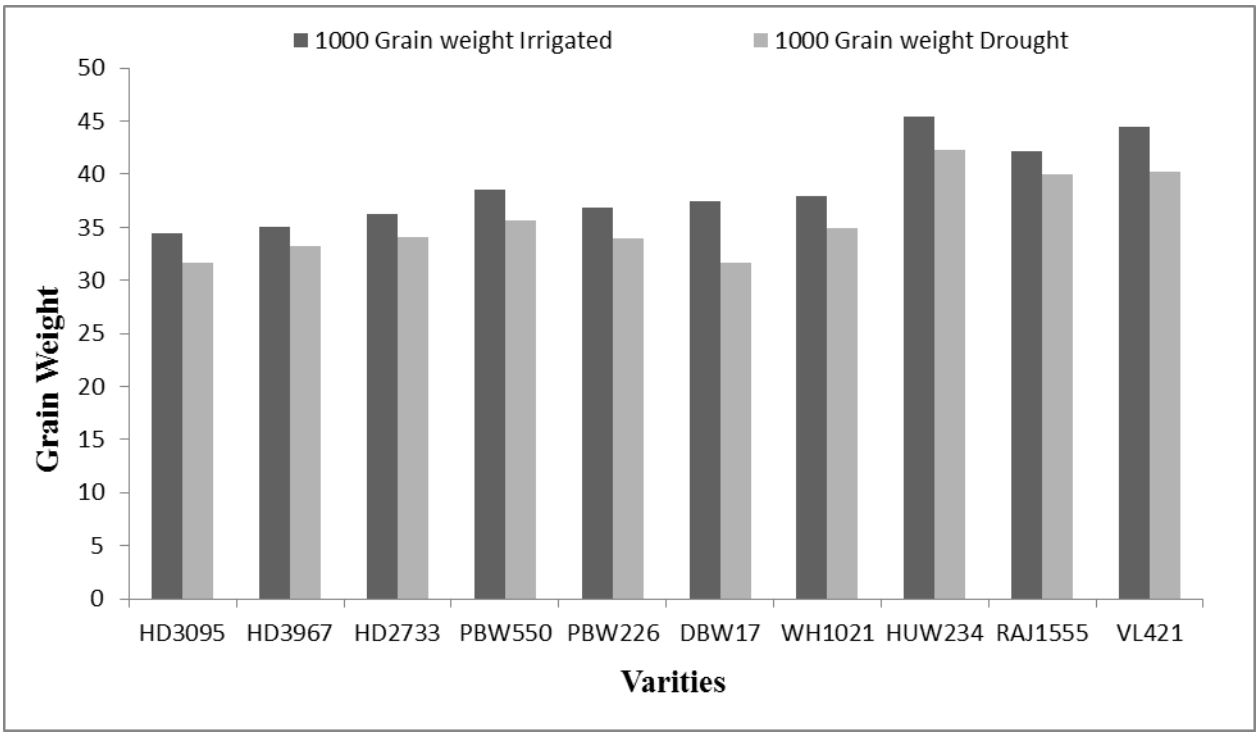


Fig.2e Grain yield per plant of different genotypes of wheat under control and drought conditions

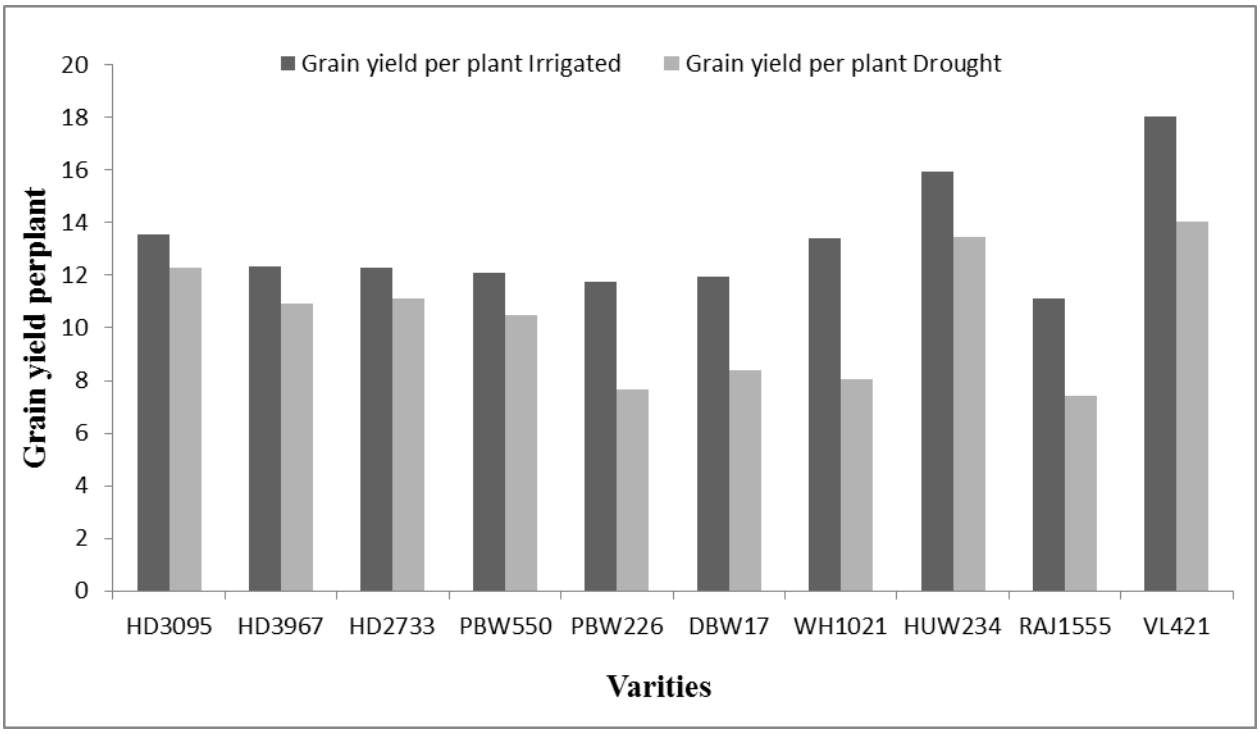


Fig.3a Related Water Content (RWC) of different genotypes of wheat under irrigated and drought conditions

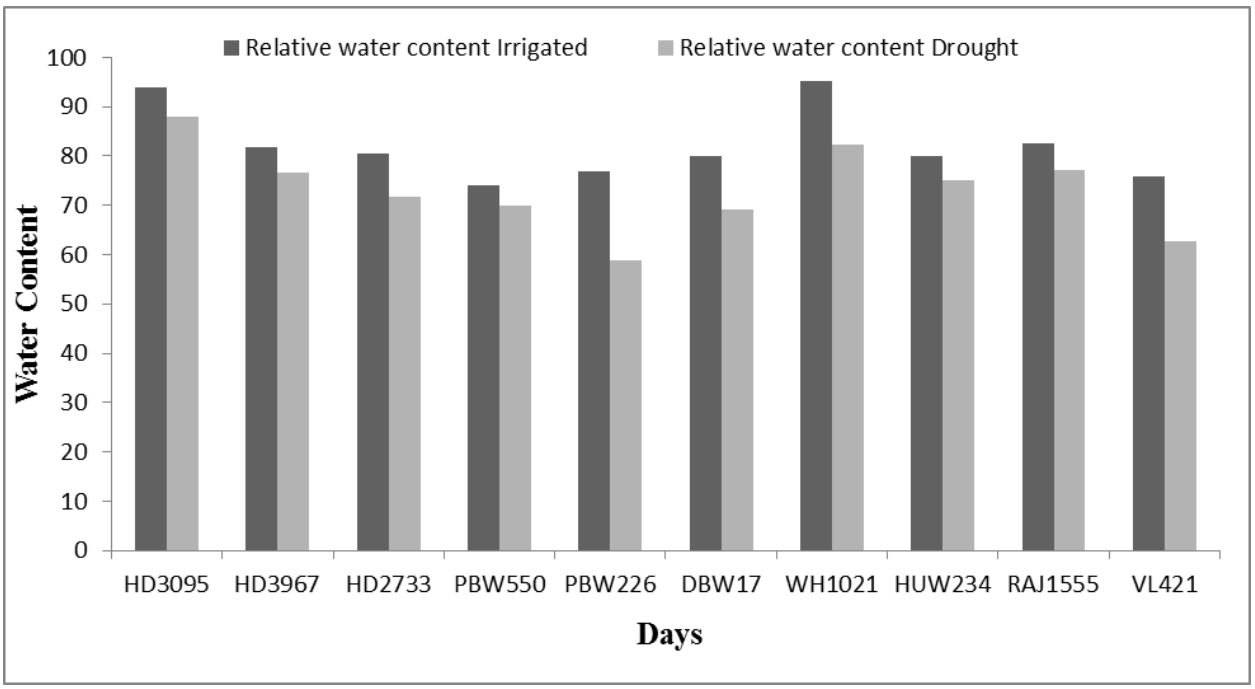
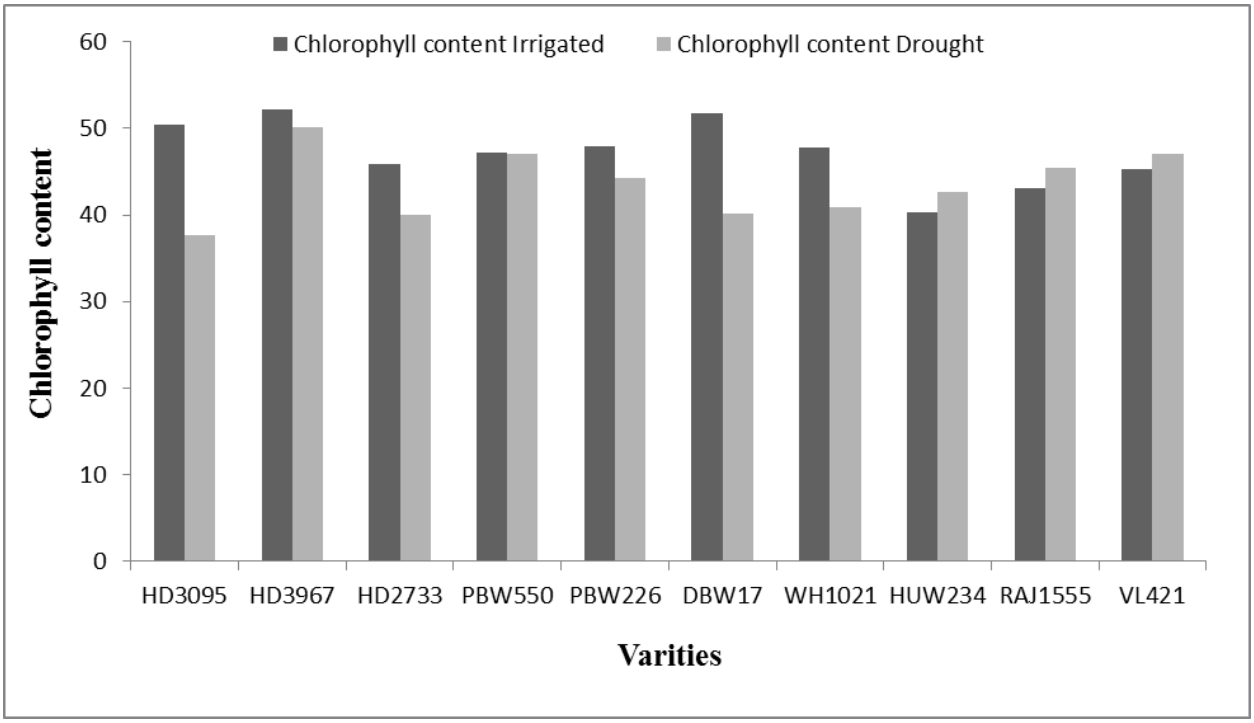


Fig.3b Chlorophyll content of different genotypes of wheat under irrigated and drought conditions



Physiological characteristics

The Relative water content (RWC) estimated for the wheat genotypes in controlled and water stress condition were calculated and summarized in Table 3 and Figure 3a. The RWC in irrigated plants varied from 74.1% (PBW 550) to 94.0% (HD 3095) in control, while in drought conditions it varied from 58.0% (PBW 226) to 88.0 % (HD 3095). Leaf RWC is of the best growth/biochemical indices revealing the stress intensity. Leaf RWC is of the best growth/biochemical indices revealing the stress intensity (Alizade, 2002). The rate of RWC in plant with high resistance against drought is higher than others. In other words, plant having higher yields under drought stress should have high RWC. So, based on these results, mentioned genotypes which are classified as high and medium yielding genotypes in condition of drought stress, should be of high-content RWC. Decrease in RWC in plants under drought stress may depend on plant vigor reduction and have been observed in many genotypes (Liu *et al*., 2002).

Chlorophyll content observed that with irrigated conditions chlorophyll content varied from 43.1 (Raj 1555) to 52.2 (HD3967), while under drought stress it was observed from lower value 37.6 (HD 3095) to the highest value 50.2 (HD3967 (Table 3 and Fig. 3b). In three genotypes i.e. HUW 234, Raj 1555 and VL 421 showed increased level of chlorophyll content when exposed to drought conditions when compared to control (irrigated conditions). Chlorophyll is one of the major chloroplast components for photosynthesis and relative chlorophyll content has a positive relationship with photosynthetic rate and flag leaf chlorophyll content is an indicator of the photosynthetic activity and its stability for the conjugation of assimilate biosynthesis.

It is concluded on the basis of various morphological and physiological characters we can summarize that genotypes Raj 1555, DBW 17, PBW 226, VL 421, and WH 1021 performed better to resists the drought conditions. The Physiological characteristics as RWC, and chlorophyll content of wheat genotypes were investigated under irrigated (control) and drought conditions. On the basis of chlorophyll content the genotypes HUW 234, Raj 1555 and VL 421 showed increase in the chlorophyll while in rest of genotypes it decreased. On the basis of Relative water content (RWC) in drought stress conditions genotype gave less RWC PBW 226 as it showed the lowest RWC among all the genotypes.

Thus, the analysis gives an insight of the inter relationship among the genotypes and highlights the urgency of effective supplementation of sufficient phenotypic and molecular basis to efficiently unearth the reliable genetic interrelationship among the genotypes. Following conclusions could be drawn from the present investigation:

1. Ten genotypes of wheat were analysed for various morphological and physiological characters under drought stress conditions and compare them with Irrigated conditions.

Few genotypes mainly Raj 1555, DBW 17, PBW 226, VL 421, and WH 1021 performed better for drought induced conditions.

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